



COURSE FILE FOR THE ACADEMIC YEAR 2017-18

COURSE: I YEAR B.TECH - II SEM

SUBJECT: APPLIED PHYSICS

COURSE FILE(R-16)

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Vision of the institute

To be recognized as a premier institution in offering value based and futuristic quality technical education to meet the technological needs of the society.

Mission of the institute

- 1.To impart value based quality technical education through innovative teaching and learning methods.

2.To continuously produce employable technical graduates with advanced technical skills to meet the current and future technological needs of the society.

3.To prepare the graduates for higher learning with emphasis on academic and industrial research.

LIST OF COS

Subject Name: Applied Physics

YEAR: I YEAR II SEM

Branch: MECH

Regulation: R16

CO1	Summarize the three module of elasticity, and estimate them strength of a material.
CO2	Recall Sabine's formula for reverberation time and apply in architecture of buildings.
CO3	Discuss various methods of producing ultrasonic's and their uses.
CO4	Identify deferent Di-electric materials and evaluate their pole strength.

CO5

Choose various magnetic materials based on their properties.

CO6

Define super conductivity and **differentiate** the types of super conductors.

LIST OF POS

PROGRAM OUTCOMES (PO's):

Engineering Graduates will be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. Conduct investigations of complex problems: Use researchbased knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development
8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

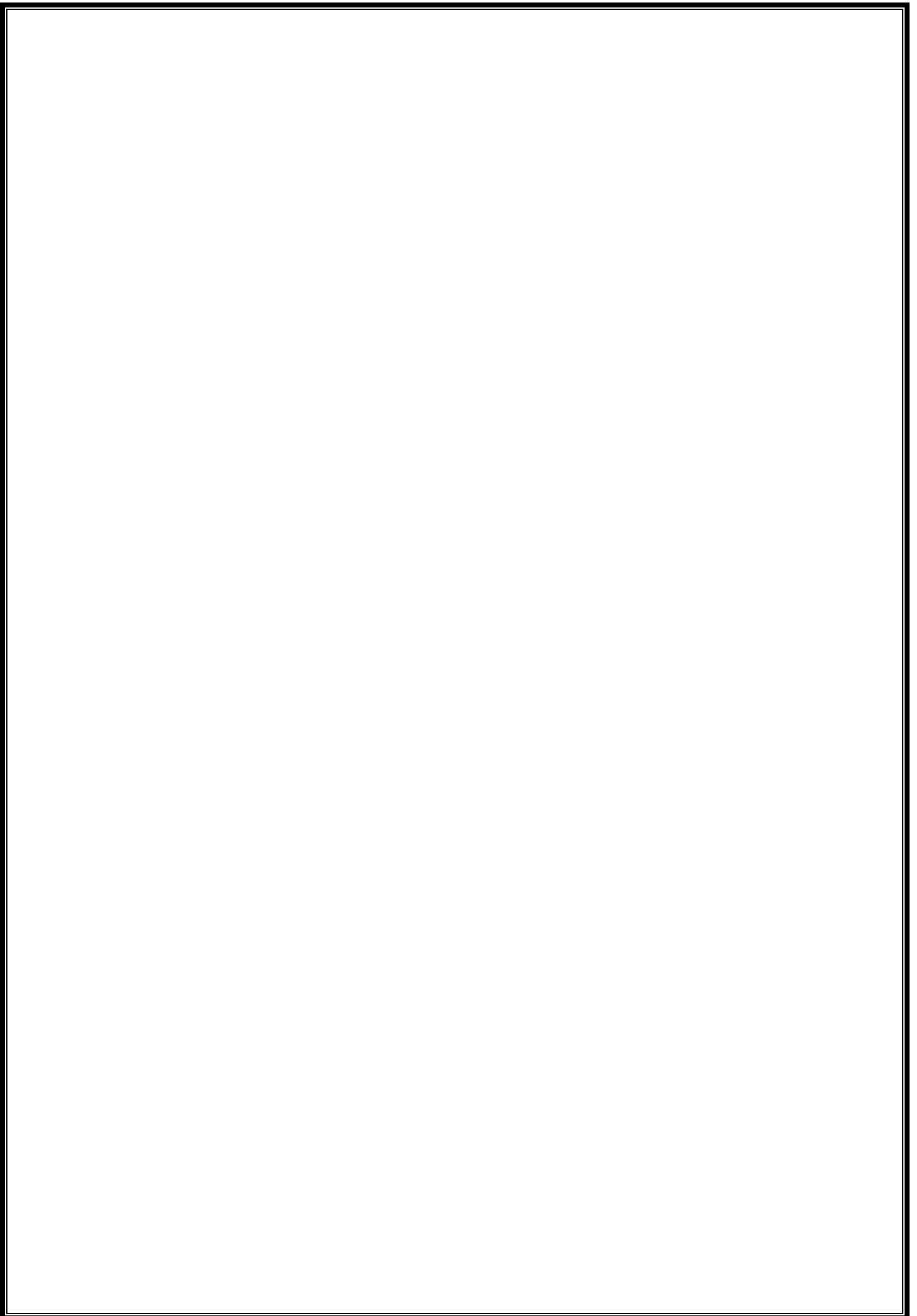
10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Lifelong learning: Recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.

CO PO MAPPING

COURSE CO-PO MATRIX	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
C102.1	3	2	2	-	1	-	-	-	-	-	-	-
C102.2	3	2	2	-	1	-	-	-	-	-	-	-
C102.3	3	2	2	-	1	-	-	-	-	-	-	-
C102.4	3	2	2	-	1	-	-	-	-	-	-	-
C102.5	3	2	2	-	1	-	-	-	-	-	-	-
C102.6	3	2	2	-	1	-	-	-	-	-	-	-



AP201BS: APPLIED PHYSICS

B.Tech. I Year II Sem.

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UNIT - I

Elastic properties: stress and strain, Hooke's law, elastic behavior of a material, factors affecting elasticity, three moduli of elasticity, work done for unit volume in deforming a body, relation between three moduli of elasticity, determination of rigidity modulus – torsional pendulum.

UNIT - II

Acoustics of buildings and acoustic quieting: Introduction, basic requirement for the acoustically good halls, reverberation and time of reverberation, transmission of sound and transmission loss, factors affecting the architectural acoustics and their remedy, sound absorbing materials, Sabine formulae, absorption coefficients, stadium seating, movie theater, acoustic quieting.

UNIT - III

Ultrasonics: Introduction, production of ultrasonic waves, magnetostriction method, piezo electric method, detection of ultrasonic waves, properties of ultrasonic waves, use of ultrasonics for nondestructive testing, applications of ultrasonics.

UNIT - IV

Dielectric Properties: Electric dipole, dipole moment, dielectric constant, polarizability, electric susceptibility, displacement vector, electronic, ionic and orientation polarizations and calculation of their polarizabilities, internal field, Clausius-Mossotti relation, Piezoelectricity, pyroelectricity and ferroelectricity-BaTiO₃ structure.

UNIT - V

Magnetic Properties: Permeability, field intensity, magnetic field induction, magnetization, magnetic susceptibility, origin of magnetic moment, Bohr magneton, classification of dia, para

and ferro magnetic materials on the basis of magnetic moment, hysteresis curve based on domain theory, soft and hard magnetic materials, properties of anti-ferro and ferri magnetic materials.

Superconductivity: Superconductivity phenomenon, Meissner effect, applications of superconductivity.

Text books:

1. Solid State Physics, A. J. Dekkar, MacMillan publishers
2. Fundamentals of Physics, Alan Giambattisa, BM Richardson and Robert C Richardson, Tata McGraw hill Publishers
3. Fundamentals of Acoustics, Kinster and Frey, John Wiley and Sons.

Reference Books:

1. Solid state physics, Charles Kittel, Wiley student edition
2. University Physics, Francis W. Sears, Hugh D. Young, Marle Zeemansky and Roger A Freedman, Pearson Education.
3. Introduction to Magnetic Materials, B.D. Cullity, C.D.Graham, A John Wiley & Sons, Inc., Publication.
4. Elastic and Inelastic Stress Analysis, Irving H. Shames, Francis A. Cozzarelli, Taylor, & Francis Group.

Lesson Plan		Subject: Applied Physics	
Topic	No. of lectures	Text books	
Unit-1			
Elastic properties: Introduction, stress and strain	L1,L2	T1	
Hooke's law, elastic behavior	L3	T1	

of material		
Factors affecting elasticity	L4	T1
Elastic moduli	L5,L6	T1
Work done for unit volume in deforming a body	L7	T1
Relation between elastic moduli	L7,L8	T1
Determination of rigidity modulus using torsional pendulum	L9	T1
Torsional pendulum experiment	L10	T1
Unit-II		
Acoustic of buildings and acoustic quieting: Introduction, basic requirement for acoustically good halls	L11,L12	T3
Reverberation, time of reverberation	L13,L14	T3
Transmission of sound and transmission loss	L15, L16	T3
Factors affecting the architectural acoustic and remedy	L17, L18	T3
Sound absorbing materials	L19	T3
Sabine's formulae	L20, L21	T3
Absorption coefficients	L22	T3
Stadium seating, movie theater	L23	T3
Acoustic quieting	L24,L25	T3
Unit-III		
Ultrasonic: Introduction	L26	T2,T3
Production of ultrasonic waves-Magnetostriction method	L27	T2,T3
Production of ultrasonic waves-Piezo-electric method	L28	T2,T3
Detection of ultrasonic waves	L29, L30	T2,T3
Properties of ultrasonic waves	L31	T2,T3
Uses of ultrasonics for non destructive methods	L32, L33	T2,T3
Applications of ultrasonics	L34	T2,T3
Unit -IV		
Dielectric properties: Introduction, dipole	L35	T1,T2
Dipole moment Dielectric constant Polarisability	L36	T1,T2
Electric susceptibility	L37	T1,T2
Displacement Vector	L38	T1,T2
Ionic and orientation polarization	L39	T1,T2
Calculation of their polarizabilities	L40, L41	T1,T2

Internal field	L42	T1,T2
Claussius - Mossotti Relation	L43	T1,T2
Piezoelectricity	L44	T1,T2
Pyro-electricity and Ferroelectricity	L45	T1,T2
BaTiO ₃ Structure	L46	T1,T2
Unit -V		
Magnetic Properties& superconductivity: Introduction	L47	T1,T2
Permeability, Field intensity	L48	T1,T2
Magnetic field Induction, Magnetization	L49	T1,T2
Magnetic susceptibility	L50	T1,T2
Origin of magnetic moment	L51	T1,T2
Bohr Magneton	L52	T1,T2
Classification of Dia, Para, and Ferro magnetic materials on the basis of magnetic moment	L53	T1,T2
Hysteresis curve based on Domain theory	L54	T1,T2
Soft and hard magnetic materials	L55	T1,T2
Properties of anti ferro and ferri magnetic materials	L56	T1,T2
Super conductivity: Introduction	L57	T1,T2
Superconductivity phenomenon	L58	T1,T2
Meissner Effect	L59	T1,T2
Applications of superconductivity	L60	T1,T2

SESSION EXECUTION LOG

SNO	UNIT	DURATION
1	Elastic properties: Introduction, stress and strain Hooke's law	19-12-2017 - 06-01-2018

	<p>elastic behavior of material Factors affecting elasticity Elastic moduli Work done for unit volume in deforming a body Relation between elastic moduli Determination of rigidity modulus using torsional pendulum Torsional pendulum experiment</p>	
2	<p>Acoustic of buildings and acoustic quieting: Introduction, basic requirement for acoustically good halls Reverberation, time of reverberation Transmission of sound and transmission loss Factors affecting the architectural acoustic and remedy Sound absorbing materials Sabine's formulae Absorption coefficients Stadium seating, movie theater Acousting quieting</p>	08-01-2018 - 27-01-2018
3	<p>Ultrasonic: Introduction Production of ultrasonic waves- Magnetostriction method Production of ultrasonic waves- Piezo-electric method Detection of ultrasonic waves Properties of ultrasonic waves Uses of ultrasonics for non destructive methods Applications of ultrasonics</p>	29-01-2018 - 19-02-2018
4	<p>Dielectric properties: Introduction, dipole Dipole moment Dielectric constant Polarisability Electric susceptibility Displacement Vector Ionic and orientation polarization Calculation of their polarizabilities Internal field in solids Clausius - Mossotti Relation Piezoelectricity Pyro-electricity and Ferroelectricity BaTiO₃ Structure</p>	22-02-2018 - 28-02-2018
5	<p>Magnetic Properties & superconductivity: Introduction</p>	03-03-2018 - 24-03-2018

	Permeability, Field intensity Magnetic field Induction, Magnetization Magnetic susceptibility Origin of magnetic moment Bohr Magneton Classification of Dia, Para, and Ferro magnetic materials on the basis of magnetic moment Hysteresis curve based on Domain theory Soft and hard magnetic materials Properties of anti ferro and ferri magnetic materials Super conductivity: Introduction Superconductivity phenomenon Meissner Effect Applications of superconductivity	
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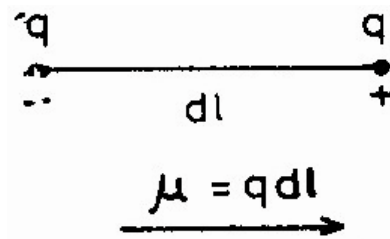
UNIT - III

DIELECTRIC PROPERTIES

Introduction:

Dielectrics are insulating materials. In dielectrics, all the electrons are bound to their parent molecules and there are no free charges. Even with normal voltage or thermal energy, electrons are not released.

Electric Dipole: A system consisting of two equal and opposite charges separated by a distance is called electric dipole.



Dipole moment: The product of charge and distance between two charges is called dipole moment.

$$\text{i.e., } \mu = q \times dl$$

Permittivity: It is a quantity, which represents the dielectric property of a medium. Permittivity of a medium indicates the easily Polarizable nature of the material.

Units: Faraday / Meter or Coulomb / Newton-meter .

Dielectric constant: The dielectric characteristics are determined by the dielectric constant. The dielectric constant or relative permittivity of a medium is defined as the ratio between the permittivity of the medium to the permittivity of the free space.

$$\epsilon_r = \epsilon / \epsilon_0 = C / C_0 \quad \text{where}$$

ϵ is permittivity of the medium

ϵ_0 is permittivity of the free space

C is the capacitance of the capacitor with dielectric

C_0 is the capacitance of the capacitor without dielectric

Units: No Units.

Capacitance: The property of a conductor or system of conductor that describes its ability to store electric charge.

$$C = q / V = A \epsilon / d \quad \text{where}$$

C is capacitance of capacitor

q is charge on the capacitor plate

V is potential difference between plates

A is area of capacitor plate

ϵ is permittivity of medium

d is distance between capacitor plates

Units: Farad.

Polarizability (α) : When the strength of the electric field E is increased the strength of the induced dipole μ also increases . Thus the induced dipole moment is proportional to the intensity of the electric field.

$$\mu = \alpha E$$

where α the constant of proportionality is called polarizability

.It can be defined as induced dipole moment per unit electric field.

$$\alpha = \mu / E$$

Units: Farad – meter²

Polarization Vector (P) : The dipole moment per unit volume of the dielectric material is called polarization vector **P** .if μ is the average dipole moment per molecule and N is the number of molecules per unit volume then polarization vector

$$P = N \mu$$

The dipole moment per unit volume of the solid is the sum of all the individual dipole moments within that volume and is called the polarization of the solid.

Electric Flux Density or Electric Displacement (D): The Electric Flux Density or Electric

Displacement at a point in the material is given by

$$D = \epsilon_r \epsilon_0 E \text{ -----(1) where}$$

E is electric field strength

ϵ_r is relative permittivity of material

ϵ_0 is permittivity of free space

As polarization measures additional flux density arising from the presence of the material as compared to free space, it has same units as D.

Hence $D = \epsilon_0 E + P$ -----(2) Since D =

$$\epsilon_0 \epsilon_r E$$

$$\epsilon_0 \epsilon_r E = \epsilon_0 E + P \Rightarrow P = \epsilon_0 \epsilon_r E - \epsilon_0 E$$

$$P = \epsilon_0 (\epsilon_r - 1) E.$$

Electric Susceptibility (χ_e): The polarization **P** is proportional to the total electronic flux density E and is in the same direction of E. Therefore, the polarization vector can be written as

$$P = \epsilon_0 \chi_e E$$

$$\text{Therefore } \chi_e = P / \epsilon_0 E = \epsilon_0 (\epsilon_r - 1) E / \epsilon_0 E$$

$$\chi_e = (\epsilon_r - 1)$$

Dielectric Strength: It can be defined as the minimum voltage required for producing dielectric breakdown. Dielectric strength decreases with raising the temperature, humidity and age of the material.

Various polarization Process: polarization occurs due to several atomic mechanisms. When a specimen is placed in a d.c. electric field, polarization is due to four types of processes. They are

- (1) electronic polarization
- (2) ionic polarization
- (3) orientation polarization and
- (4) space charge polarization

Electronic Polarization: the process of producing electric dipoles which are oriented along the field direction is called polarization in dielectrics

Consider an atom placed inside an electric field. The centre of positive charge is displaced along the applied field direction while the centre of negative charge is displaced in the opposite direction .thus a dipole is produced.

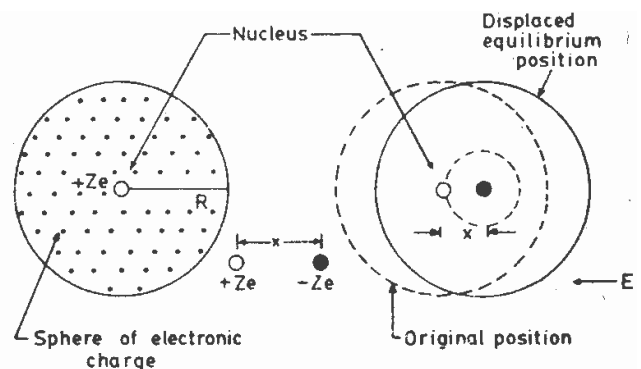
The displacement of the positively charged nucleus and the negative electrons of an atom in opposite directions, on application of an electric field, result in electronic polarization.

Induced dipole moment

$$\mu \propto E \text{ or } \mu = \alpha_e E \text{ where } \alpha_e \text{ is electronic polarizability}$$

Electronic polarizability is independent of temperature.

Derivation: Consider the nucleus of charge Ze is surrounded by an electron cloud of charge $-Ze$ distributed in a sphere of radius R .



Charge density ρ is given by

$$\rho = -Ze / \left(\frac{4}{3}\pi R^3 \right) = -\frac{3}{4} \left(\frac{Ze}{\pi R^3} \right) \quad \text{-----(1)}$$

When an external field of intensity E is applied, the nucleus and electrons experiences Lorentz forces in opposite direction. Hence the nucleus and electron cloud are pulled apart.

Then Coulomb force develops between them, which tends to oppose the displacement. When Lorentz and coulomb forces are equal and opposite, equilibrium is reached.

Let x be the displacement

$$\text{Lorentz force} = -Ze E \quad (\text{since} = \text{charge} \times \text{applied field})$$

$$\text{Coulomb force} = Ze x \left[\frac{\text{charge enclosed in sphere of radius 'x'}}{4 \pi \epsilon_0 x^2} \right]$$

$$\text{enclosed} = \left(\frac{4}{3} \right) \pi x^3 \rho$$

$$= \left(\frac{4}{3} \right) \pi x^3 \left[\left(-\frac{3}{4} \right) \left(\frac{Ze}{\pi R^3} \right) \right]$$

$$= -Ze x^3 / R^3$$

$$\text{Therefore Coulomb force} = (Ze) \left(-Ze x^3 / R^3 \right) / 4 \pi \epsilon_0 x^2 = -Z^2 e^2 x / 4 \pi \epsilon_0 R^3$$

At equilibrium, Lorentz force = Coulomb force

$$\textcircled{2} \quad -Ze E = -Z^2 e^2 x / 4 \pi \epsilon_0 R^3$$

$$\textcircled{2} \quad E = -Ze x / 4 \pi \epsilon_0 R^3$$

$$\textcircled{2} \quad \text{or } x = 4 \pi \epsilon_0 R^3 E / Ze$$

Thus displacement of electron cloud is proportional to applied field.

The two charges $+Ze$ and $-Ze$ are separated by a distance 'x' under applied field constituting induced electric dipoles .

Induced dipole moment $\mu_e = Ze x$

$$\text{Therefore } \mu_e = Ze (4 \pi \epsilon_0 R^3 E / Ze) = 4 \pi \epsilon_0 R^3 E$$

Therefore $\mu_e \propto E$, $\mu_e = \alpha_e E$ where $\alpha_e = 4 \pi \epsilon_0 R^3$ is electronic polarizability

The dipole moment per unit volume is called electronic polarization. It is independent of temperature.

$$\mathbf{P} = N \mu_e = N \alpha_e E \text{ where}$$

N is Number of atoms / m^3

$$\mathbf{P}_e = N (4 \pi \epsilon_0 R^3 E) = 4 \pi \epsilon_0 R^3 N E \text{ where}$$

R is radius of atom

Electric Susceptibility $\chi = \mathbf{P} / \epsilon_0 E$

Therefore $\mathbf{P} = \epsilon_0 E \chi$

$$\mathbf{P} = (4 \pi R^3 N) \epsilon_0 E \quad \text{where } \chi = 4 \pi R^3 N$$

Also $\mathbf{P}_e = \epsilon_0 E (\epsilon_r - 1) = N \alpha_e E$ Or

$$\epsilon_r - 1 = N \alpha_e / \epsilon_0$$

Hence $\alpha_e = \epsilon_0 (\epsilon_r - 1) / N$.

Ionic Polarization: It is due to the displacement of cat ions and anions in opposite directions and occurs in an ionic solid .

Consider a NaCl molecule. Suppose an electric field is applied in the positive direction . The positive ion moves by x_1 and the negative ion moves by x_2

Let M is mass of positive ion

M is mass of negative ion

x_1 is displacement of positive ion x_2

is displacement of negative ion

Total displacement $x = x_1 + x_2$ -----(1)

Lorentz force on positive ion = + e E -----(2)

Lorentz force on negative ion = - e E -----(3)

Restoring force on positive ion = - $k_1 x_1$ ----- (2 a)

Restoring force on negative ion = + $k_2 x_2$ ----- (3 a)

where k_1, k_2 Restoring force constants

At equilibrium, Lorentz force and restoring force are equal and opposite

For positive ion, $e E = k_1 x_1$

For negative ion, $e E = k_2 x_2$]----- (4)

Where $k_1 = M \omega_0^2$ & $k_2 = m \omega_0^2$

where ω_0 is angular velocity of ions

Therefore $x = x_1 + x_2 = (e E / \omega_0^2) [1/M + 1/m]$ -----(5) From definition of dipole moment

$\mu = \text{charge} \times \text{distance of separation}$

$$\mu = e x = (e^2 E / \omega_0^2) [1/M + 1/m] \text{ -----(6)}$$

But $\mu \propto E$ or $\mu = \alpha_i E$

Therefore $\alpha_i = (e^2 / \omega_0^2) [1/M + 1/m]$

This is ionic polarizability.

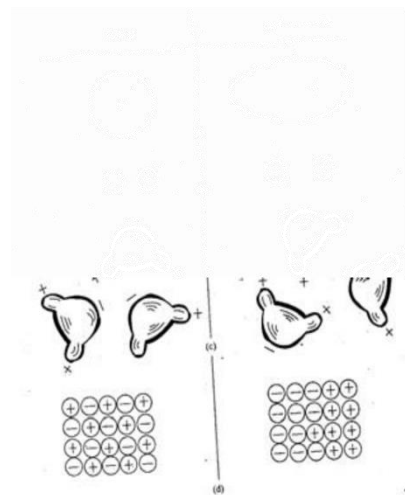
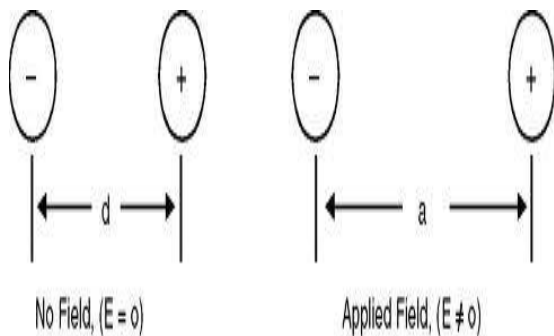


Fig. 1.1 Various polarization processes: (a) electronic polarization, (b) ionic polarization, (c) orientation polarization, and (d) space charge polarization.

Orientational Polarization :

In methane molecule, the centre of negative and positive charges coincides, so that there is no permanent dipole moment. On the other hand, in certain molecules such as CH3Cl, the positive and negative charges do not coincide. Even in the absence of an electric field, this molecule carries a dipole moment, they tend to align themselves in the direction of applied field. The polarization due to such alignment is called orientation polarization. It is dependent on temperature. With increase of temperature the thermal energy tends to randomize the alignment.

Orientalional polarization $P_o = N\mu = N\mu_2E / 3kT$

$$= N \alpha_0 E$$

Therefore Orientalional polarizability $\alpha_0 = P_o / NE = \mu^2 / 3kT$

Thus orientalional polarizability α_0 is inversely proportional t absolute temperature of material.

Internal field or Local field or Lorentz field: Internal field is the total electric field at atomic site.

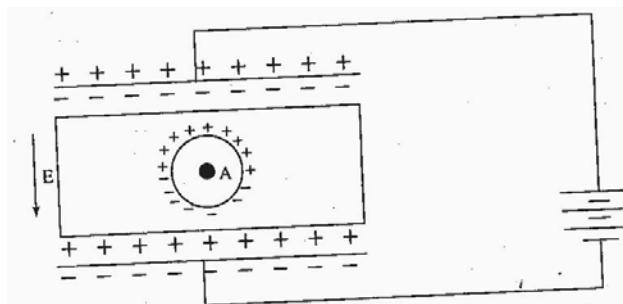
Internal field $A = E_1 + E_2 + E_3 + E_4$ ----- (I) where

E_1 is field intensity due to charge density on plates

E_2 is charge density induced on two sides of dielectric

E_3 is field intensity due to other atoms in cavity and

E_4 is field intensity due to polarization charges on surface of cavity



Field E1: E_1 is field intensity due to charge density on plates

From the field theory

$$E_1 = D / \epsilon_0$$

$$D = P + \epsilon_0 E$$

Therefore $E_1 = (P + \epsilon_0 E) / \epsilon_0 = E + P / \epsilon_0$ -----(1)

Field E2: E_2 is the field intensity at A due to charge density induced on two sides of dielectric

Therefore $E_2 = - P / \epsilon_0$ -----(2)

Field E3: E_3 is field intensity at A due to other atoms contained in the cavity and for a cubic structure,

$E_3 = 0$ because of symmetry. ----- (3)

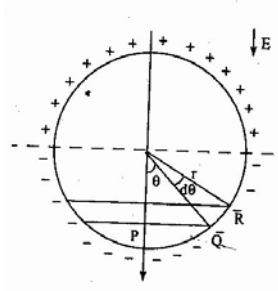
Field E4: E_4 is field intensity due to polarization charges on surface of cavity and was calculated by Lorentz in the following way:

If dA is the surface area of the sphere of radius r lying between θ and $\theta + d\theta$, where θ is the direction with reference to the direction of applied force.

Then $dA = 2 \pi (PQ) (QR)$

But $\sin \theta = PQ / r \Rightarrow PQ = r \sin \theta$

And $d\theta = QR/r \Rightarrow QR = r d\theta$



Hence $dA = 2\pi(r \sin \theta) (r d\theta) = 2\pi r^2 \sin \theta d\theta$

Charge on surface dA is $dq = P \cos \theta dA$ ($\cos \theta$ is normal component)

$$dq = P \cos \theta (2\pi r^2 \sin \theta d\theta) = P (2\pi r^2 \sin \theta \cos \theta d\theta)$$

The field due to the charge dq at A , is denoted by dE_4 in direction $\theta = 0$

$$dE_4 = dq \cos \theta / 4\pi \epsilon_0 r^2 = P (2\pi r^2 \sin \theta \cos \theta d\theta) \cos \theta$$

$$dE_4 = P \sin \theta \cos^2 \theta d\theta / 2\epsilon_0$$

$$\int dE_4 = P / 2\epsilon_0 \int_0^\pi \sin \theta \cos^2 \theta d\theta = P / 2\epsilon_0 \int_0^\pi \cos^2 \theta d(-\cos \theta)$$

Let $\cos \theta = x$

$$\int dE_4 = -P / 2\epsilon_0 \int_0^\pi x^2 dx$$

$$\text{Therefore } E_4 = -P / 2\epsilon_0 [x^3 / 3]_0^\pi$$

$$= -P / 2\epsilon_0 [\cos^3 \theta / 3]_0^\pi = -P / 6\epsilon_0 [-1 - 1] = P / 3\epsilon_0 \text{ ----- (4)}$$

Local field $E_i = E_1 + E_2 + E_3 + E_4$

$$= E + P / \epsilon_0 - P / \epsilon_0 + 0 + P / 3\epsilon_0$$

$$= E + P / 3\epsilon_0$$

Clausius – Mosotti Relation:

Let us consider the elemental dielectric having cubic structure. Since there are no ions and permanent dipoles in these materials, their ionic polarizability α_i and orientational polarizability α_0 are zero.

$$\text{i.e. } \alpha_i = \alpha_0 = 0$$

$$\text{Hence polarization } P = N \alpha_e E_i$$

$$= N \alpha_e (E + P / 3\epsilon_0)$$

$$\text{i.e. } P [1 - N \alpha_e / 3\epsilon_0] = N \alpha_e E$$

$$P = N \alpha_e E / [1 - N \alpha_e / 3\epsilon_0] \text{ ----- (1)}$$

$$D = P + \epsilon_0 E$$

$$P = D - \epsilon_0 E$$

Dividing on both sides by E

$$P / E = D / E - \epsilon_0 = \epsilon - \epsilon_0 = \epsilon_0 (\epsilon_r - 1)$$

$$P = E \epsilon_0 (\epsilon_r - 1) \text{ ----- (2)}$$

From eqn 1 and 2, we get

$$P = E \epsilon_0 (\epsilon_r - 1) = N \alpha_e E / [1 - N \alpha_e / 3\epsilon_0] [1 - N \alpha_e / 3\epsilon_0] = N \alpha_e / \epsilon_0 (\epsilon_r - 1)$$

$$1 = N \alpha_e / 3\epsilon_0 + N \alpha_e / \epsilon_0 (\epsilon_r - 1)$$

$$1 = (N \alpha_e / 3 \epsilon_0) (1 + 3 / (\epsilon_r - 1))$$

$$1 = (N \alpha_e / 3 \epsilon_0) [(\epsilon_r - 1 + 3) / (\epsilon_r - 1)]$$

$$1 = (N \alpha_e / 3 \epsilon_0) [(\epsilon_r + 2) / (\epsilon_r - 1)]$$

$$(\epsilon_r + 2) / (\epsilon_r - 1) = N \alpha_e / 3 \epsilon_0 \quad \text{Where } N - \text{no of molecules per unit volume}$$

This is Clausius – Mosotti Relation.

Dielectric Breakdown : The dielectric breakdown is the sudden change in state of a dielectric material subjected to a very high electric field , under the influence of which , the electrons are lifted into the conduction band causing a surge of current , and the ability of the material to resist the current flow suffers a breakdown .

Or

When a dielectric material loses its resistivity and permits very large current to flow through it, then the phenomenon is called dielectric breakdown.

There are many factors for dielectric breakdown which are (1) Intrinsic breakdown (2) Thermal breakdown (3) Discharge breakdown (4) Electro Chemical breakdown (5) Defect breakdown.

(1) **Intrinsic breakdown:** The dielectric strength is defined as the breakdown voltage per unit thickness of the material. When the applied electric field is large, some of the electrons in the valence band cross over to the conduction band across the large forbidden energy gap giving rise to large conduction currents. The liberation or movement of electrons from valence band is called field emission of electrons and the breakdown is called the intrinsic breakdown or zener breakdown

The number of covalent bonds broken and the number of charge carriers released increases

enormously with time and finally dielectric breakdown occurs. This type of breakdown is called Avalanche breakdown.

(2) **Thermal breakdown:** It occurs in a dielectric when the rate of heat

generation is greater than the rate of dissipation. Energy due to the dielectric loss appears as heat. If the rate of generation of heat is larger than the heat dissipated to the surrounding, the temperature of the dielectric increases which eventually results in local melting. Once melting starts, that particular region becomes highly conductive, enormous current flows through the material and dielectric breakdown occurs.

Thus thermal breakdown occurs at very high temperatures. Since the dielectric loss is directly proportional to the frequency, for a.c fields, breakdown occurs at relatively lower field strengths.

(3) **Discharge breakdown:** Discharge breakdown is classified as external or internal. External breakdown is generally caused by a glow or corona discharge. Such discharges are normally observed at sharp edges of electrodes. It causes deterioration of the adjacent dielectric medium. It is accompanied by the formation of carbon so that the damaged areas become conducting leading to power arc and complete failure of the dielectric. Dust or moisture on the surface of the dielectric may also cause external discharge breakdown. Internal breakdown occurs when the insulator contains blocked gas bubbles. If a large number of gas bubbles is present, this can occur even at low voltages.

(4) **Electro Chemical breakdown:** Chemical and electro chemical breakdown are related to thermal breakdown. When temperature rises, mobility of ions increases and hence electrochemical reaction takes place. When ionic mobility increases leakage current also increases and this may lead to dielectric breakdown. Field induced chemical reaction gradually decreases the insulation resistance and finally results in breakdown.

(5) **Defect breakdown:** If the surface of the dielectric material has defects such as cracks and porosity, then impurities such as dust or moisture collect at these discontinuities leading to breakdown. Also if it has a defect in the form of strain in the material, that region will also break on application of electric field.

Frequency dependence of polarizability:

On application of an electric field, polarization process occurs as a function of

time. The polarization $P(t)$ as a function of time. The polarization $P(t)$ as a function of time t is given by

$$P(t) = P[1 - \exp(-t/t_r)]$$

Where P – max. Polarization attained on prolonged application of static field. t_r -

relaxation time for particular polarization process

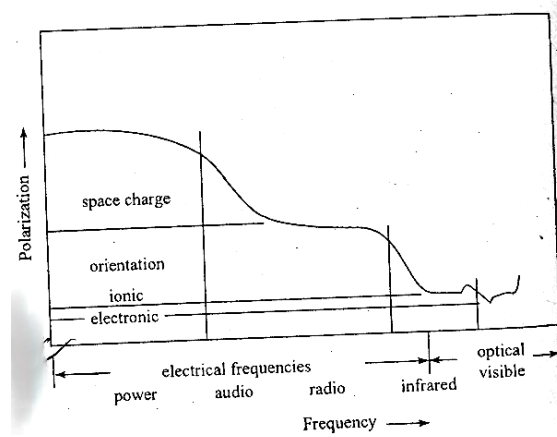
The relaxation time t_r is a measure of the time scale of polarization process. It is the time taken for a polarization process to reach 0.63 of the max. value.

Electronic polarization is extremely rapid. Even when the frequency of the applied voltage is very high in the optical range ($\approx 10^{15}$ Hz), electronic polarization occurs during every cycle of the applied voltage.

Ionic polarization is due to displacement of ions over a small distance due to the applied field. Since ions are heavier than electron cloud, the time taken for displacement is larger. The frequency with which ions are displaced is of the same order as the lattice vibration frequency ($\approx 10^{13}$ Hz). Hence, at optical frequencies, there is no ionic polarization. If the frequency of the applied voltage is less than 10^{13} Hz, the ions respond.

Orientation polarization is even slower than ionic polarization. The relaxation time for orientation polarization in a liquid is less than that in a solid. Orientation polarization occurs, when the frequency of applied voltage is in audio range (10¹⁰ Hz).

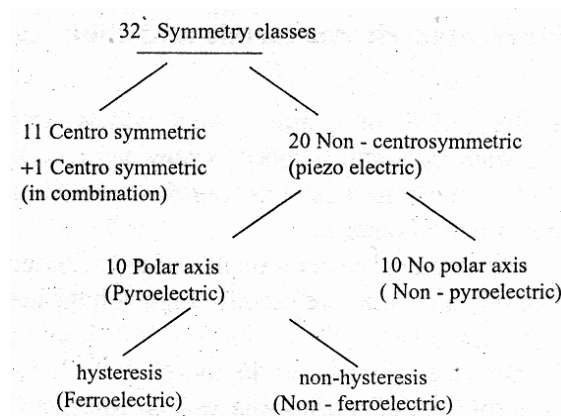
Space charge polarization is the slowest process, as it involves the diffusion of ions over several interatomic distances. The relaxation time for this process is related to frequency of ions under the influence of applied field. Space charge polarization occurs at power frequencies (50-60 Hz).



Piezo – Electricity: These materials have the property of becoming electrically polarized when mechanical stress is applied. This property is known as Piezo – electric effect has an inverse

.According to inverse piezo electric effect, when an electric stress or voltage is applied, the material becomes strained. The strain is directly proportional to the applied field E.

When piezo electric crystals are subjected to compression or tension, opposite kinds of charges are developed at the opposite faces perpendicular to the direction of applied force. The charges produced are proportional to the applied force.



Piezo – Electric Materials and Their Applications: Single crystal of quartz is used for filter, resonator and delay line applications. Natural quartz is now being replaced by synthetic material.

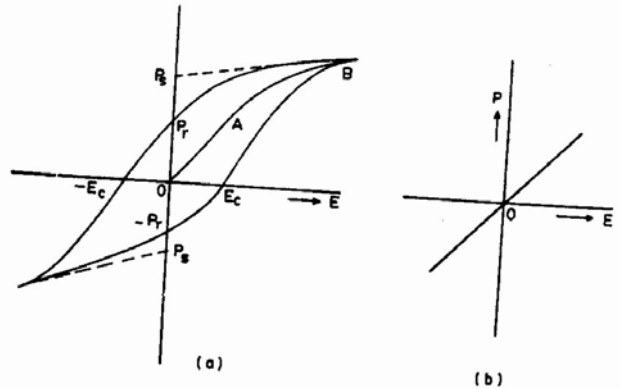
Rochelle salt is used as transducer in gramophone pickups, ear phones,

hearing aids, microphones etc. the commercial ceramic materials are based on barium titanate, lead zirconate and lead titanate. They are used for high voltage generation (gas lighters),

accelerometers, transducers etc.

ultrasonic waves. Piezo electric semiconductors such as GaS, ZnO & CdS are used as amplifiers

Ferro electricity: Ferro electric materials are an important group not only because of intrinsic Ferro electric property, but because many possess useful piezo electric, birefringent and electro optical properties.



The intrinsic Ferro electric property is the possibility of reversal or change of orientation of the polarization direction by an electric field. This leads to hysteresis in the polarization P, electric field E relation, similar to magnetic hysteresis. Above a critical temperature, the Curie point T_c , the spontaneous polarization is destroyed by thermal disorder. The permittivity shows a characteristic peak at T_c .

Pyroelectricity: It is the change in spontaneous polarization when the temperature of specimen is changed.

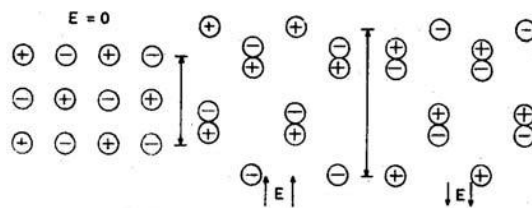


Fig. Displacements of the ions under an electric field

Pyroelectric coefficient ' λ ' is defined as the change in polarization per unit temperature change of specimen.

$$\lambda = dP / dT$$

change in polarization results in change in external field and also changes the surface.

Required Qualities of Good Insulating Materials: The required qualities can be classified as under electrical, mechanical, thermal and chemical applications.

Electrical: 1. electrically the insulating material should have high electrical resistivity and high dielectric strength to withstand high voltage.

2. The dielectric losses must be minimum.

3. Liquid and gaseous insulators are used as coolants. For example transformer oil, hydrogen and helium are used both as insulators and coolant.

ii) Mechanical: 1. insulating materials should have certain mechanical properties depending on the use to which they are put.

2. When used for electric machine insulation, the insulator should have sufficient mechanical strength to withstand vibration.

iii) Thermal: Good heat conducting property is also desirable in such cases. The insulators should have small thermal expansion and it should be non-ignitable.

iv) Chemical: 1. chemically, the insulators should be resistant to oils, liquids, gas fumes, acids and alkali's.

2. The insulators should be water proof since water lowers the insulation resistance and the dielectric strength.

MAGNETIC PROPERTIES

Introduction: The basic aim in the study of the subject of magnetic materials is to understand the effect of an external magnetic field on a bulk material, and also to account for its specific behavior. A dipole is an object that has a magnetic pole at one end and an equal and opposite second magnetic pole at the other end.

A bar magnet can be considered as a dipole with a north pole at one end and a South Pole at the other. If a magnet is cut into two, two magnets or dipoles are created out of one. This sectioning and creation of dipoles can continue to the atomic level. Therefore, the source of magnetism lies in the basic building block of all matter i.e. the atom.

Consider electric current flowing through a conductor. When the electrons are flowing through the conductor, a magnetic field is formed around the conductor. A magnetic field is produced whenever an electric charge is in motion. The strength of the field is called the **magnetic moment**.

Magnetic materials are those which can be easily magnetized as they have a permanent magnetic moment in the presence of an applied magnetic field. Magnetism arises from the magnetic dipole moments. It is responsible for producing magnetic influence of attraction or repulsion.

Magnetic dipole : it is a system consisting of two equal and opposite magnetic poles separated by a small distance of '2l' metre.

Magnetic Moment (μ_m) : It is defined as the product of the pole strength (m) and the distance between the two poles (2l) of the magnet.

$$\text{i.e.} \dots \mu_m = (2l) m$$

Units: Ampere – metre²

Magnetic Flux Density or Magnetic Induction (B): It is defined as the number of magnetic lines of force passing perpendicularly through unit area.

i . e . . \mathbf{B} = magnetic flux / area = Φ / A

Units: Weber / metre² or Tesla.

Permeability:

Magnetic Field Intensity (H): The magnetic field intensity at any point in the magnetic field is the force experienced by a unit north pole placed at that point.

Units: Ampere / meter

The magnetic induction B due to magnetic field intensity H applied in vacuum is related by

$$\mathbf{B} = \mu_0 \mathbf{H} \text{ where } \mu_0 \text{ is permeability of free space} = 4 \pi \times 10^{-7} \text{ H / m}$$

If the field is applied in a medium, the magnetic induction in the solid is given by

$$\mathbf{B} = \mu \mathbf{H} \quad \text{where } \mu \text{ is permeability of the material in the medium}$$

$$\mu = B / H$$

Hence magnetic Permeability μ of any material is the ratio of the magnetic induction to the applied magnetic field intensity. The ratio of μ / μ_0 is called the relative permeability (μ_r).

$$\mu_r = \mu / \mu_0$$

Therefore $\mathbf{B} = \mu_0 \mu_r \mathbf{H}$

Magnetization: It is the process of converting a non – magnetic material into a magnetic material. The intensity of magnetization (M) of a material is the magnetic moment per unit volume. The intensity of magnetization is directly related to the applied field H through the susceptibility of the medium (χ) by

$$\chi = M / H \text{ -----(1)}$$

The magnetic susceptibility of a material is the ratio of the intensity of magnetization produced to the magnetic field intensity which produces the magnetization. It has no units.

We know

$$B = \mu H$$

$$= \mu_0 \mu_r H$$

$$\text{i.e } B = \mu_0 \mu_r H + \mu_0 H - \mu_0 H$$

$$= \mu_0 H + \mu_0 H (\mu_r - 1)$$

$$= \mu_0 H + \mu_0 M \quad \text{where } M \text{ is magnetization} = H (\mu_r - 1)$$

$$\text{i.e } B = \mu_0 (H + M) \text{ -----(2)}$$

The first term on the right side of eqn (2) is due to external field. The second term is due to the magnetization.

$$\text{Hence } \mu_0 = \frac{B}{H + M}$$

Relative Permeability ,

$$\mu_r = \mu / \mu_0 = (B / H) / (B / H + M) = H + M / H = 1 + M / H$$

$$\mu_r = 1 + \chi \text{ -----(3)}$$

The magnetic properties of all substances are associated with the orbital and spin motions of the electrons in their atoms. Due to this motion, the electrons become elementary magnets of the substance. In few materials these elementary magnets are able to strengthen the applied magnetic field, while in few others, they orient themselves such that the applied magnetic field is weakened.

Origin of Magnetic Moment : In atoms, the permanent magnetic moments can arise due to the following :

1. the orbital magnetic moment of the electrons
2. the spin magnetic moment of the electrons
3. the spin magnetic moment of the nucleus.

Orbital magnetic moment of the electrons: In an atom, electrons revolve round the nucleus in different circular orbits.

Let m be the mass of the electron and r be the radius of the orbit in which it moves with angular velocity ω .

The electric current due to the moving electron $I = -$ (number of electrons flowing per second \times charge of an electron)

Therefore $I = - e \omega / 2 \pi \text{ -----(1)}$

The current flowing through a circular coil produces a magnetic field in a direction perpendicular to the area of coil and it is identical to the magnetic dipole. the magnitude of the magnetic moment produced by such a dipole is

$$\mu_m = I . A$$

$$= (- e \omega / 2 \pi) (\pi r^2)$$

$$= -e \omega r^2 / 2 = (-e / 2 m) (m \omega r^2) = - (e / 2 m) L \text{ -----(2)}$$

where $L = m \omega r^2$ is the orbital angular momentum of electron. The minus sign indicates that the magnetic moment is anti – parallel to the angular momentum L. A substance therefore possesses permanent magnetic dipoles if the electrons of its constituent atom have a net non-vanishing angular momentum. The ratio of the magnetic dipole moment of the electron due to its orbital motion and the angular momentum of the orbital motion is called orbital gyro magnetic ratio , represented by γ .

$$\text{Therefore } \gamma = \text{magnetic moment} / \text{angular momentum} = e / 2m$$

The angular momentum of an electron is determined by the orbital quantum number 'l' given by $l = 0, 1, 2, \dots, (n - 1)$ where n is principal quantum number $n = 1, 2, 3, 4, \dots$ corresponding to K, L, M, N.....shells .

The angular momentum of the electrons associated with a particular value of l is given by $l (h / 2 \pi)$

The strength of the permanent magnetic dipole is given by

$$\mu_{el} = - (e / 2 m) (l h / 2 \pi)$$

$$\text{i.e } \mu_{el} = - (e h l / 4 \pi m) = - \mu_B l \text{ -----(3)}$$

The quantity $\mu_B = e h / 4 \pi m$ is an atomic unit called Bohr Magneton and has a value 9.27×10^{-24} ampere metre²

In an atom having many electrons, the total orbital magnetic moment is determined by taking the algebraic sum of the magnetic moments of individual electrons. The moment of a completely filled shell is zero. An atom with partially filled shells will have non zero orbital magnetic moment.

Magnetic Moment Due to Electron Spin : The magnetic moment associated with spinning of the electron is called spin magnetic moment μ_{es} .Magnetic moment due to the rotation of the electronic charge about one of the diameters of the electron is similar to the earth's spinning motion around it's north – south axis.

An electronic charge being spread over a spherical volume, the electron spin would cause different charge elements of this sphere to form closed currents, resulting in a net spin magnetic moment. This net magnetic moment would depend upon the structure of the electron and its charge distribution.

$$\mu_{es} = \gamma (e / 2m) S \text{ -----(1) where } S = h / 4\pi \text{ is spin angular momentum}$$

$$\text{therefore } \mu_{es} \approx 9.4 \times 10^{-24} \text{ ampere metre}^2$$

Thus, the magnetic moments due to the spin and the orbital motions of an electron are of the same order of magnitude. The spin and electron spin magnetic moment are intrinsic properties of an electron and exist even for a stationary electron. Since the magnitude of spin magnetic moment is always same, the external field can only influence its direction. If the electron spin moments are free to orient themselves in the direction of the applied field B. In a varying field, it experiences a force in the direction of the increasing magnetic field due to spin magnetic moments of its various electrons.

Magnetic Moment due to Nuclear Spin : Another contribution may arise from the nuclear magnetic moment. By analogy with Bohr Magneton, the nuclear magneton arises due to spin of the nucleus. It is given by

$$\mu_{ps} = e h / 4\pi M_p$$

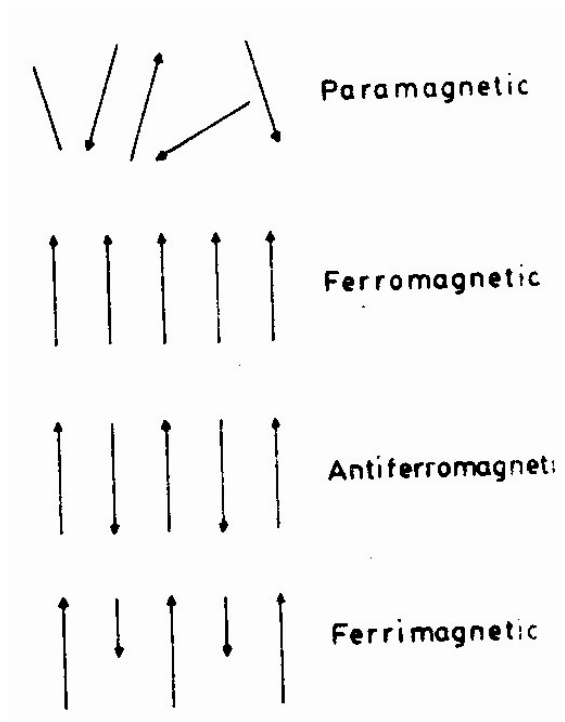
$$\mu_{ps} = 5.05 \times 10^{-27} \text{ ampere metre}^2 \text{ where } M_p \text{ is mass of}$$

proton. The nuclear magnetic moments are smaller than those associated with electrons.

Classification Of Magnetic Materials : All matter respond in one way or the other when subjected to the influence of a magnetic field. The response could be strong or weak, but there is none with zero response i.e., there is no matter which is non magnetic in the absolute sense. Depending upon the magnitude and sign of response to the applied field, and also on the basis of effect of temperature on the magnetic properties, all materials are classified broadly under 3 categories.

1. Diamagnetic materials 2. Paramagnetic materials, 3. Ferromagnetic materials

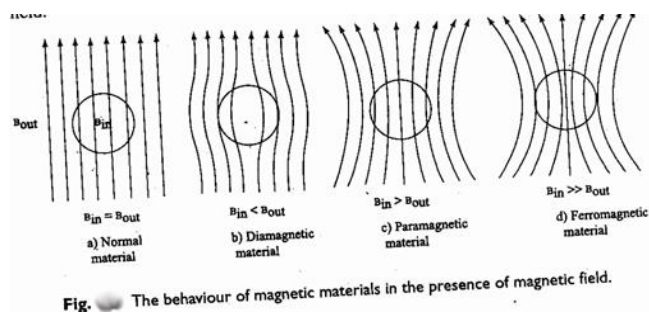
two more classes of materials have structure very close to ferromagnetic materials but possess quite different magnetic effects. They are i. Anti ferromagnetic materials and ii . Ferri magnetic materials



1. **Diamagnetic materials:** *Diamagnetic* materials are those which experience a repelling force when brought near the pole of a strong magnet. In a non uniform magnetic field they are repelled away from stronger parts of the field.

In the absence of an external magnetic field , the net magnetic dipole moment over each atom or molecule of a diamagnetic material is zero.

Ex: Cu, Bi , Pb .Zn and rare gases.



Paramagnetic materials: Paramagnetic materials are those which experience a feeble attractive force when brought near the pole of a magnet. They are attracted towards the stronger parts of magnetic field. Due to the spin and orbital motion of the electrons, the atoms of paramagnetic material possess a net intrinsic permanent moment.

Susceptibility χ is positive and small for these materials. The susceptibility is inversely

proportional to the temperature T.

$$\chi \propto 1/T$$

$$\chi = C/T \quad \text{where } C \text{ is Curie's temperature.}$$

Below superconducting transition temperatures, these materials exhibit the Para magnetism.

Examples: Al, Mn, Pt, CuCl_2 .

Ferromagnetic Materials: Ferromagnetic materials are those which experience a very strong attractive force when brought near the pole of a magnet. These materials, apart from getting magnetized parallel to the direction of the applied field, will continue to retain the magnetic property even after the magnetizing field removed. The atoms of ferromagnetic materials also have a net intrinsic magnetic dipole moment which is due to the spin of the electrons.

Susceptibility is always positive and large and it depends upon temperature.

$$\chi = C / (T - \theta) \quad (\text{only in paramagnetic region i.e., } T > \theta)$$

θ is Curie's temperature.

When the temperature of the material is greater than its Curie temperature then it converts into paramagnetic material.

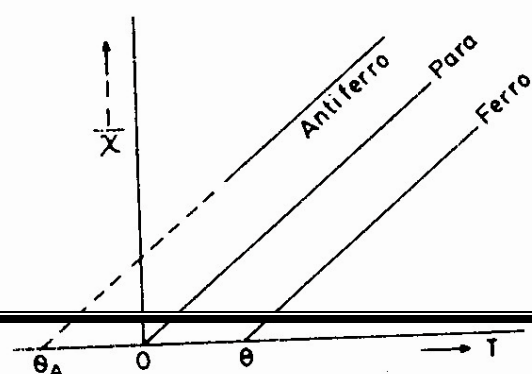
Examples: Fe, Ni, Co, MnO .

Antiferromagnetic materials : These are the ferromagnetic materials in which equal no of opposite spins with same magnitude such that the orientation of neighbouring spins is in antiparallel manner are present.

Susceptibility is small and positive and it is inversely proportional to the temperature.

$$\chi = C / (T + \theta)$$

the temperature at which anti ferromagnetic material converts into paramagnetic material is known as Neel's temperature. Examples: FeO , Cr_2O_3 .



Ferrimagnetic materials: These are the ferromagnetic materials in which equal no of opposite spins with different magnitudes such that the orientation of neighbouring spins is in antiparallel manner are present.

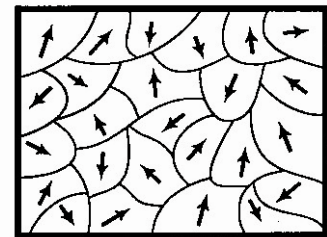
Susceptibility positive and large, it is inversely proportional to temperature

$$\chi = C / (T \pm \theta) \quad T > T_N \text{ (Neel's temperature)}$$

Examples : $ZnFe_2O_4$, $CuFe_2O_4$

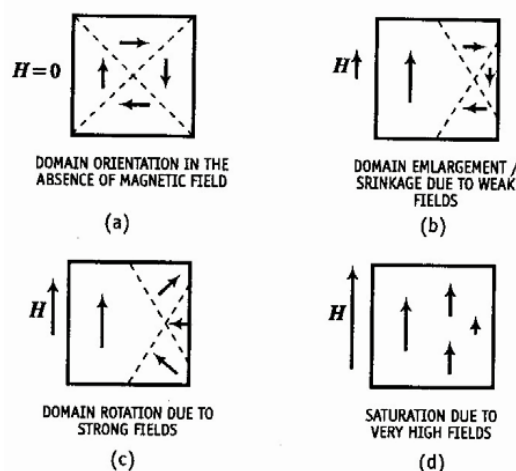
Domain theory of ferromagnetism: According to Weiss, a virgin specimen of ferromagnetic material consists of a no of regions or domains ($\approx 10^{-6}$ m or larger) which are spontaneously magnetized. In each domain spontaneous magnetization is due to parallel alignment of all magnetic dipoles. The direction of spontaneous magnetization varies from domain to domain. The resultant magnetization may hence be zero or nearly zero. When an external field is applied there are two possible ways of alignment for a random domain.

i). **By motion of domain walls:** The volume of the domains that are favourably oriented with respect to the magnetizing field increases at the cost of those that are unfavourably oriented



RANDOM ORIENTATION OF MAGNETIC MOMENTS OF THE DOMAINS

ii) **By rotation of domains:** When the applied magnetic field is strong, rotation of the direction of magnetization occurs in the direction of the field.



Hysteresis curve (study of B-H curve): The hysteresis of ferromagnetic materials refers to the lag of magnetization behind the magnetization field. when the temperature of the ferromagnetic substance is less than the ferromagnetic Curie temperature ,the substance exhibits hysteresis. The domain concept is well suited to explain the phenomenon of hysteresis. The increase in the value of the resultant magnetic moment of the specimen by the application of the applied field , it attributes to the 1. motion of the domain walls and 2. rotation of domains.

When a weak magnetic field is applied, the domains that are aligned parallel to the field and in the easy direction of magnetization , grow in size at the expense of less favorably oriented ones. This results in Bloch wall movement and when the weak field is removed, the domains reverse back to their original state. This reverse wall displacement is indicated by OA of the magnetization curve. When the field becomes stronger ,the Bloch wall movement continues and it is mostly irreversible movement. This is indicated by the path AB of the graph. The phenomenon of hysteresis is due to this irreversibility.

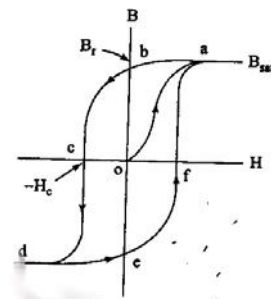
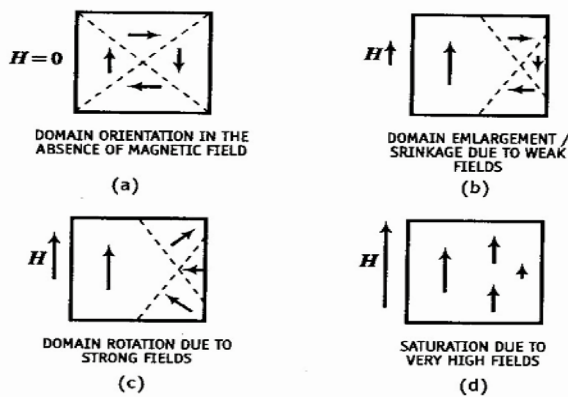


Fig. Schematic representation of the hysteresis loop for a ferromagnetic material.

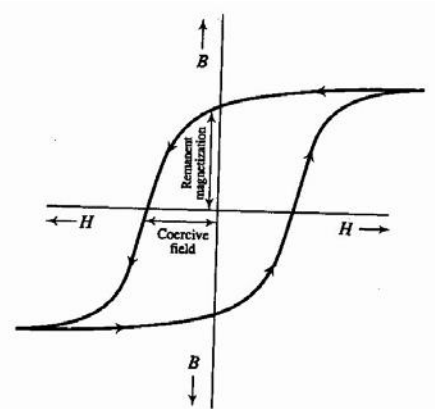
At the point B all domains have got magnetized along their easy directions. Application of still higher fields rotates the domains into the field direction which may be away from the easy direction. Once the domain rotation is complete the specimen is saturated denoted by C. on removal of the field the specimen tends to attain the original configuration by the movement of Bloch walls. But this movement is hampered by the impurities, lattice imperfections etc, and so more energy must be supplied to overcome the opposing forces. This means that a coercive field is required to reduce

the magnetization of the specimen to zero. The amount of energy spent in this regard is a loss. Hysteresis loss is the loss of energy in taking a ferromagnetic body through a complete cycle of magnetization and this loss is represented by the area enclosed by the hysteresis loop.

A hysteresis curve shows the relationship between the magnetic flux density B and applied magnetic field H . It is also referred to as the B - H curve (loop).

Hard and Soft Magnetic Materials:

Hysteresis loop of the ferromagnetic materials vary in size and shape. This variation in hysteresis loops leads to a broad classification of all the magnetic materials into hard type and soft type.



HYSTERESIS CURVE FOR HARD MAGNETIC MATERIAL

HardMagneticMaterials:

Hard magnetic materials are those which are characterized by large hysteresis loop because of which they retain a considerable amount of their magnetic energy after the external magnetic field is switched off. These

materials are subjected to a magnetic field of increasing intensity, the domain walls movements are impeded due to certain factors. The cause for such a nature is attributed to the presence of impurities or non-magnetic materials, or the lattice imperfections. Such defects attract the domain walls thereby reducing the wall energy. It results in a stable state for the domain walls and gives mechanical hardness to the material which increases the electrical resistivity. The increase in electrical resistivity brings down the eddy current loss if used in a.c conditions. The hard magnetic materials can neither be easily magnetized nor easily demagnetized.

Properties:

1. High remanent magnetization
2. High coercivity
3. High saturation flux density
4. Low initial permeability
5. High hysteresis energy loss
6. High permeability
7. The eddy current loss is low for ceramic type and large for metallic type.

Examples of hard magnetic materials are, i) Iron- nickel- aluminum alloys with certain amount of cobalt called Alnico alloy. ii) Copper nickel iron alloys. iii) Platinum cobalt alloy.

Applications of hard magnetic materials: For production of permanent magnets, used in magnetic detectors, microphones, flux meters, voltage regulators, damping devices and magnetic separators.

Soft Magnetic Materials:

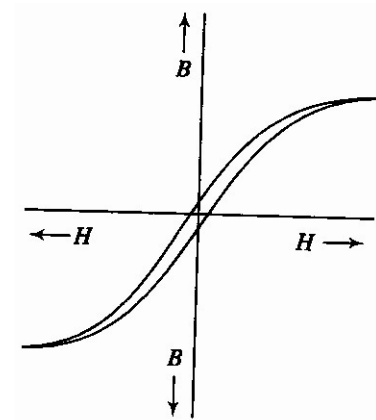
Soft magnetic materials are those for which the hysteresis loops enclose very small area. They are the magnetic materials which cannot be permanently magnetized. In these materials, the domain walls motion occurs easily. Consequently, the coercive force assumes a small value and makes

the hysteresis loop a narrow one because of which, the hysteresis loss

becomes very small. For the same reasons, the materials can be easily magnetized and demagnetized.

Properties:

1. Low remanent magnetization
2. Low coercivity
3. Low hysteresis energy loss
4. Low eddy current loss
5. High permeability
6. High susceptibility



HYSTERESIS CURVE FOR SOFT
MAGNETIC MATERIAL

Examples of soft magnetic materials are

- i) Permalloys (alloys of Fe and Ni)
- ii) Si – Fe alloy
- iii) Amorphous ferrous alloys (alloys of Fe, Si, and B)
- iv) Pure Iron (BCC structure)

Applications of soft magnetic materials: Mainly used in electro- magnetic machinery and transformer cores. They are also used in switching circuits, microwave isolators and matrix storage of computers.

SUPERCONDUCTIVITY

Introduction : Certain metals and alloys exhibit almost zero resistivity(i.e. infinite conductivity) when they are cooled to sufficiently low temperatures. This phenomenon is called superconductivity. This phenomenon was first observed by H.K. Onnes in 1911. He found that when pure mercury was cooled down to below 4K, the resistivity suddenly dropped to zero. Since then hundreds of superconductors have been discovered and studied. Superconductivity is strictly a low temperature phenomenon. Few new oxides exhibited superconductivity just below 125K itself. This interesting phenomena has many important applications in many emerging fields.

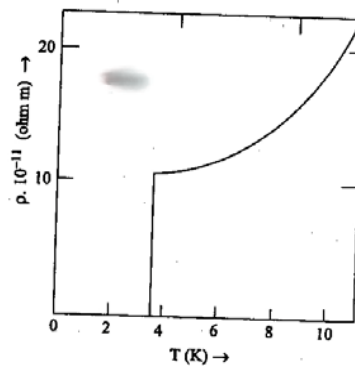


Fig. The electrical resistivity ρ of tin, as a function of temperature near 0K.

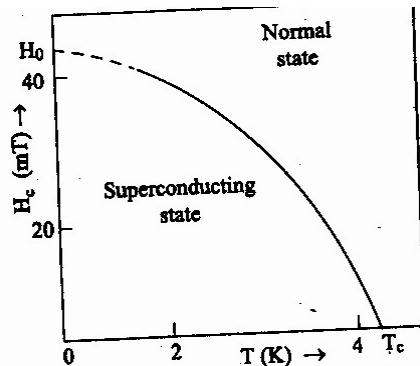
General Properties: The temperature at which the transition from normal state to superconducting state takes place on cooling in the absence of magnetic field is called the critical temperature (T_c) or the transition temperature.

The following are the general properties of the superconductors:

1. The transition temperature is different to different substances.
2. For a chemically pure and structurally perfect specimen, the superconducting transition is very sharp.
3. Superconductivity is found to occur in metallic elements in which the number of valence electrons lies between 2 and 8.

4. Transition metals having odd number of valence electrons are favourable to exhibit superconductivity while metals having even number of valence electrons are unfavourable.
5. Materials having high normal resistivities exhibit superconductivity.
6. Materials for which $Z\rho > 106$ (where Z is the no. of valence electrons and ρ is the resistivity) show superconductivity.
7. Ferromagnetic and antiferromagnetic materials are not superconductors.
8. The current in a superconducting ring persists for a very long time.

Effect of Magnetic Field: Superconducting state of metal depends on temperature and strength of the magnetic field in which the metal is placed. Superconducting disappears if the temperature of the specimen is raised above T_c or a strong enough magnetic field applied. At temperatures below T_c , in the absence of any magnetic field, the material is in superconducting state. When the strength of the magnetic field applied reaches a critical value H_c the superconductivity disappears.



At $T = T_c$, $H_c = 0$. At temperatures below T_c , H_c increases. The dependence of the critical field upon the temperature is given by

$$H_C(T) = H_C(0) [1 - (T/T_c)^2] \text{-----(1)}$$

Where $H_C(0)$ is the critical field at 0K. $H_C(0)$ and T_c are constants of the characteristics of the material.

Meissner effect: When a weak magnetic field applied to super conducting specimen at a temperature below transition temperature T_c , the magnetic flux lines are expelled. This specimen acts as on ideal diamagnet. This effect is called meissner effect. This effect is reversible, i.e. when the temperature is raised from below T_c , at $T = T_c$ the flux lines suddenly start penetrating and the specimen returns back to the normal state. Under this condition, the magnetic induction inside the specimen is given by

$$B = \mu_0(H + M) \text{-----(2)}$$

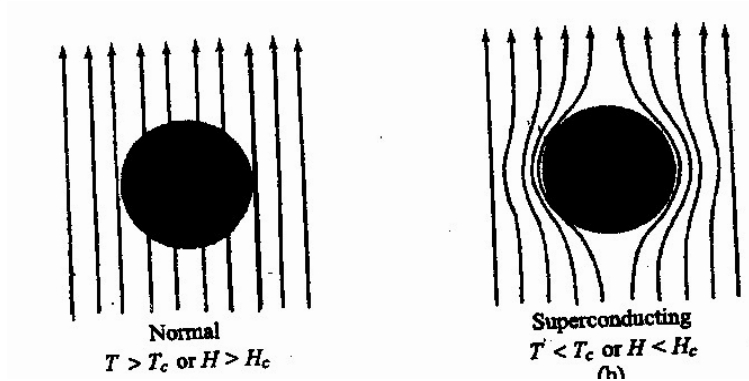
Where H is the external applied magnetic field and M is the magnetization produced inside the specimen.

When the specimen is super conducting, according to meissner effect inside the bulk semiconductor $B=0$.

Hence $\mu_0(H + M) = 0$

Or $M = -H \text{-----(3)}$

Thus the material is perfectly diamagnetic.



Magnetic susceptibility can be expressed as

$$\chi = M/H = -1 \text{-----} (4)$$

Consider a superconducting material under normal state. Let J be the current passing through the material of resistivity ρ . From ohm's law we know that the electric field

$$E = J\rho$$

On cooling the material to its transition temperature, ρ tends to zero. If J is held finite. E must be zero. From Maxwell's eqn, we know

$$\nabla \times E = - dB/ dt \quad \text{----- (5)}$$

Under superconducting condition since $E = 0$, $dB/dt = 0$, or $B = \text{constant}$.

This means that the magnetic flux passing through the specimen should not change on cooling to the transition temperature. The Meissner effect contradicts this result.

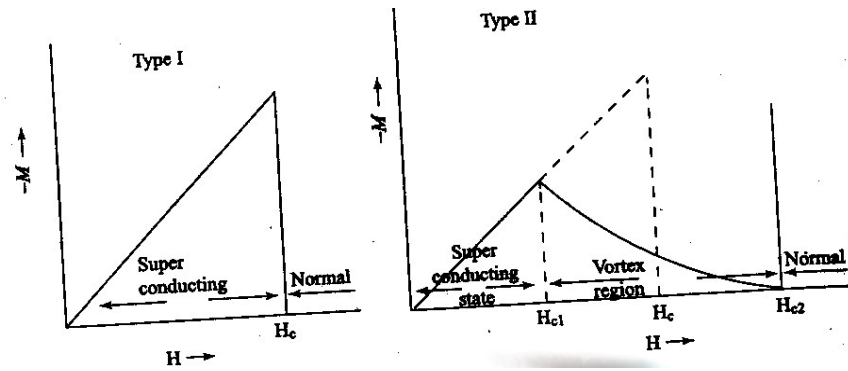
According to Meissner effect perfect diamagnetism is an essential property of defining the superconducting state. Thus

From zero resistivity $E = 0$,

From Meissner effect $B = 0$.

Type- I , Type- II superconductors: Based on diamagnetic response Superconductors are divided into two types, i.e type-I and type-II.

Superconductors exhibiting a complete Meissner effect are called type-1, also called Soft Superconductors. When the magnetic field strength is gradually increased from its initial value $H < H_C$, at H_C the diamagnetism abruptly disappear and the transition from superconducting state to normal state is sharp. Example Zn, Hg, pure specimens of Al and Sn.



In type-2 Superconductors, transition to the normal state takes place gradually. For fields below H_{C1} , the material is diamagnetic i.e., the field is completely excluded H_{C1} is called the lower critical field. At H_{C1} the field begins to penetrate the specimen. Penetration increases until H_{C2} is reached. At H_{C2} , the magnetizations vanishes i.e., the material becomes normal state. H_{C2} is the upper critical field. Between H_{C1} and H_{C2} the state of the material is called the mixed or vortex state. They are also known as hard superconductors. They have high current densities. Example Zr , Nb etc.

Questions:

1. Describe how polarization occurs in a dielectric material.
2. Define dielectric constant of a material.
3. Explain the origin of different kinds of polarization.
4. Describe in brief various types of polarization.
5. Obtain an expression for the internal field.
6. Derive Clausius - Mossotti equation.
7. Describe the frequency dependence of dielectric constant.
8. Write note on Dielectric loss.
9. Explain the properties of ferroelectric materials.

10. What is piezoelectricity?
11. Distinguish between dia, para, ferro, antiferro, and ferromagnetic materials.
12. What is meant by Neel temperature?
13. Define magnetization and show that $B = \mu_0 (H + M)$.
14. Explain the origin of magnetic moment.
15. Describe the domain theory of ferromagnetism.
16. What is Bohr Magneton.
17. Draw and explain the hysteresis curve.
18. Discuss the characteristic features of soft and hard magnetic materials.
19. What are the applications of soft and hard magnetic materials?

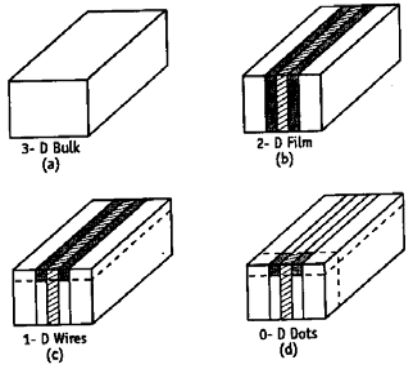
NANOTECHNOLOGY

Introduction

In 1959, Richard Feynman made a statement 'there is plenty of room at the bottom'. Based on his study he manipulated smaller units of matter. He prophesied that "we can arrange the atoms the way we want, the very atoms, all the way down". The term 'nanotechnology' was coined by Norio Taniguchi at the University of Tokyo. Nano means 10^{-9} . A nano metre is one thousand millionth of a metre (i.e. 10^{-9} m).

Nanomaterials could be defined as those materials which have structured components with size less than 100nm at least in one dimension. Any bulk material we take, its size can express in 3-

dimensions. Any planer material, its area can be expressed in 2-dimension. Any linear material, its length can be expressed in 1-dimension.



SCHEMATIC DIAGRAM OF QUANTUM STRUCTURES

Materials that are nano scale in 1-dimension or layers, such as thin films or surface coatings.

Materials that are nano scale in 2-dimensions include nanowires and nanotubes.

Materials that are nano scale in 3- dimensions are particles like precipitates, colloids and quantum dots.

Nanoscience: it can be defined as the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale.

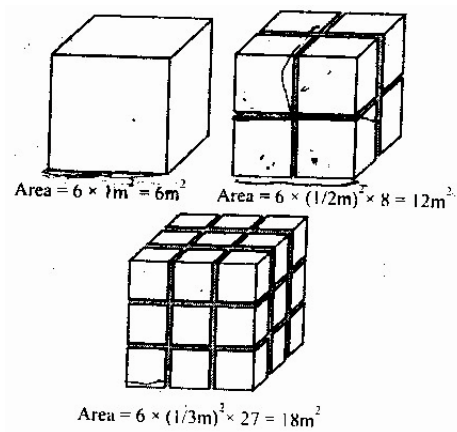
Nanotechnology: It can be defined as the design, characterization, production and application of structures, devices and systems by controlling shape and size at the nano metre scale. It is also defined as "A branch of engineering that deals with the design and manufacture of extremely small electronic circuits and mechanical devices built at molecular level of matter. Now nanotechnology crosses and unites academic fields such as Physics, Chemistry and Computer science.

Properties of nano particles:

The properties of nano scale materials are very much different from those at a larger scale. Two principal factors that cause that the properties to differ significantly are increased relative surface area and quantum effects. These can enhance or change properties such as reactivity, strength and electrical characteristics.

1. Increase in surface area to volume ratio

Nano materials have relatively larger surface area when compared to the volume of the bulk material.



Consider a sphere of radius r

Its surface area = $4\pi r^2$

Its volume = $4\pi r^3 / 3$

Surface area = $\frac{4\pi r^2}{4\pi r^3 / 3} = \frac{3}{r}$

Volume

Thus when the radius of sphere decreases, its surface area to volume ratio increases. EX:

For a cubic volume,

$$\text{Surface area} = 6 \times 1\text{m}^2 = 6\text{m}^2$$

When it is divided into 8 pieces

$$\text{Its surface area} = 6 \times (1/2\text{m})^{2 \times 8} = 12\text{m}^2$$

When the same volume is divided into 27 pieces,

$$\text{Its surface area} = 6 \times (1/3\text{m})^{2 \times 27} = 18\text{m}^2$$

Therefore, when the given volume is divided into smaller pieces, the surface area increases. Hence as particle size decreases, greater proportions of atoms are found at the surface compared to those inside. Thus nano particles have much greater surface to volume ratio. It makes material more chemically reactive.

As growth and catalytic chemical reaction occur at surfaces, then given mass of material in nano particulate form will be much more reactive than the same mass of bulk material. This affects their strength or electrical properties.

2. Quantum confinement effects

When atoms are isolated, energy levels are discrete or discontinuous. When very large number of atoms is closely packed to form a solid, the energy levels split and form bands. Nanomaterials represent an intermediate stage.

When dimensions of potential well and potential box are of the order of deBroglie wave length of electrons or mean free path of electrons, then energy levels of electrons change. This effect is called Quantum confinement effect.

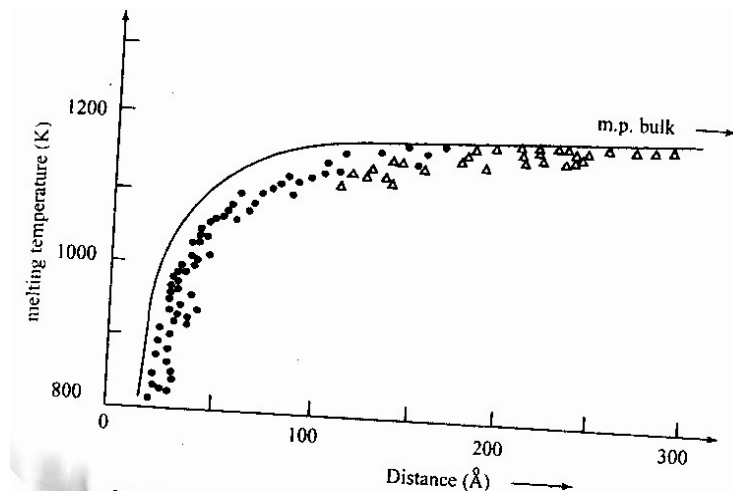
When the material is in sufficiently small size, organization of energy levels into which electrons can climb or fall changes. Specifically, the phenomenon results from electrons and holes being squeezed into a dimension that approaches a critical quantum measurement called the exciton Bohr radius. These can affect the optical, electrical and magnetic behaviour of materials.

Variations of properties of nano materials

The physical, electronic, magnetic and chemical properties of materials depend on size. Small particles behave differently from those of individual atoms or bulk.

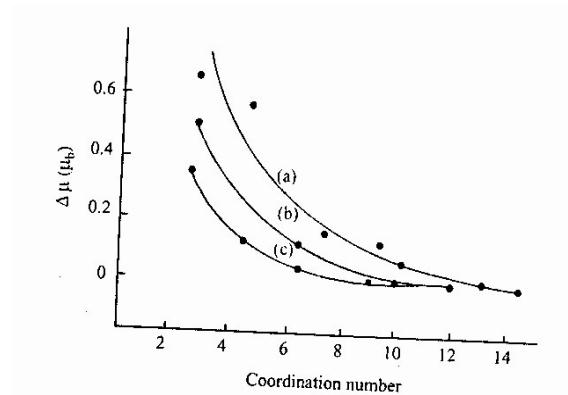
Physical properties: The effect of reducing the bulk into particle size is to create more surface sites i.e. to increase the surface to volume ratio. This changes the surface pressure and results in a change in the inter particle spacing. Thus the inter atomic spacing decreases with size.

The change in the inter particle spacing and the large surface to volume ratio in particle have a combined effect on material properties. Variation in the surface free energy changes the chemical potential. This affects the thermodynamic properties like melting point. The melting point decreases with size and at very small sizes the decrease is faster.



Chemical properties: the large surface to volume ratio, the variations in geometry and electronic structure has a strong effect on catalytic properties. The reactivity of small clusters increases rapidly

even when the magnitude of the cluster size is changed only by a few atoms.



Another important application is hydrogen storage in metals. Most metals do not absorb, hydrogen is typically absorbed dissociatively on surfaces with hydrogen- to- metal atom ratio of one. This limit is significantly enhanced in small sizes. The small positively charged clusters of Ni, Pd and Pt and containing between 2 and 60 atoms decreases with increasing cluster size. This shows that small particles may be very useful in hydrogen storage devices in metals.

Electrical properties: The ionization potential at small sizes is higher than that for the bulk and show marked fluctuations as function of size. Due to quantum confinement the electronic bands in metals become narrower. The delocalized electronic states are transformed to more localized molecular bands and these bands can be altered by the passage of current through these materials or by the application of an electric field.

In nano ceramics and magnetic nano composites the electrical conductivity increases with reduction in particle size where as in metals, electrical conductivity decreases.

Optical properties: Depending on the particle size, different colours are same. Gold nano spheres of 100nm appear orange in colour while 50nm nano spheres appear green in colour. If semiconductor particles are made small enough, quantum effects come into play, which limits the energies at which electrons and holes can exist in the particles. As energy is related to wavelength or colour, the optical properties of the particles can be finely tuned depending on its size. Thus particles can be made to emit or absorb specific wavelength of light, merely by controlling their size.

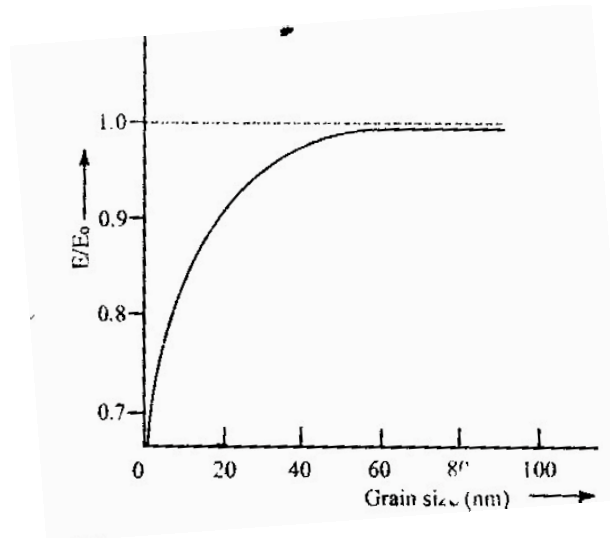
An electrochromic device consists of materials in which an optical absorption band can be introduced or an existing band can be altered by the passage of current through the materials, or by the application of an electric field. They are similar to liquid crystal displays (LCD) commonly used in calculators and watches. The resolution, brightness and contrast of these devices depend on tungstic acid gel's grain size.

Magnetic properties: The strength of a magnet is measured in terms of coercivity and saturation magnetization values. These values increase with a decrease in the grain size and an increase in the specific surface area (surface area per unit volume) of the grains.

In small particles a large number or fraction of the atoms reside at the surface. These atoms have lower coordination numbers than the interior atoms. As the coordination number decreases, the magnetic moment increases towards the atomic value. There is small particles are more magnetic than the bulk material.

Nano particles of even non-magnetic solids are found to be magnetic. It has been found theoretically and experimentally that the magnetism is special to small sizes and disappears in clusters. At small sizes, the clusters become spontaneously magnetic.

Mechanical properties: If the grains are nano scale in size, the interface area within the material greatly increases, which enhances its strength. Because of the nano size many mechanical properties like hardness, elastic modulus, fracture toughness, scratch resistance, fatigue strength are modified.



The presence of extrinsic defects such as pores and cracks may be responsible for low values of E (young's modulus) in nano crystalline materials. The intrinsic elastic moduli of nano structured materials are essentially the same as those for conventional grain size material until the grain size becomes very small. At lower grain size, the no. of atoms associated with the grain boundaries and triple junctions become very large. The hardness, strength and deformation behaviour of nano crystalline materials is unique and not yet well understood.

Super plasticity is the capability of some polycrystalline materials to exhibit very large texture deformations without fracture. Super plasticity has been observed occurs at somewhat low temperatures and at higher strain rates in nano crystalline material.

PRODUCTION OF NANOMATERIALS:

Material can be produced that are nanoscale in one dimension like thin surface coatings in two dimensions like nanowires and nanotubes or in 3 dimensions like nanoparticles

Nano materials can be synthesized by 'top down' techniques producing very small structures from larger pieces of material. One way is to mechanical crushing of solid into fine nano powder by ball milling.

Nanomaterials may also be synthesized by 'bottom up' techniques, atom by atom or molecule by molecule. One way of doing this is to allow the atoms or molecules arrange themselves into a structure due to their natural properties

Ex: - Crystals growth

PREPARATION:

There are many methods to produce nanomaterials. They are

1). PLASMA ARCING:

Plasma is an ionized gas. To produce plasma, potential difference is applied across two electrodes. The gas yields up its electrons and gets ionized. Ionized gas (plasma) conducts electricity. A plasma arcing device consists of two electrodes. An arc passes from one electrode to the other. From the anode electrode due to the potential difference electrons are emitted. Positively charged ions pass to the other electrode (cathode), pick up the electron and are deposited to form nanoparticles. As a surface deposit the depth of the coating must be only a few atoms. Each particle must be nanosized and independent. The interaction among them must be by hydrogen bonding or Vander Waals forces. Plasma arcing is used to produce carbon nanotubes.

2). CHEMICAL VAPOUR DEPOSITION:

In this method, nanoparticles are deposited from the gas phase. Material is heated to form a gas and then allowed to deposit on solid surface, usually under vacuum condition. The deposition may be either physical or chemical. In deposition by chemical reaction new product is formed. Nanopowder or oxides and carbides of metals can be formed, if vapours of carbon or oxygen are present with the metal.

Production of pure metal powders is also possible using this method. The metal is heated with microwave frequency and vaporised to produce plasma at 1500°C . This plasma then enters the reaction column cooled by water where nanosized particles are formed.

CVD can also be used to grow surfaces. If the object to be coated is introduced inside the chemical vapour, the atoms/molecules coated may react with the substrate atoms/molecules. The way the atoms /molecules grow on the surface of the substrate depends on the alignment of the atoms /molecules of the substrate. Surfaces with unique characteristics can be grown with these techniques.

3. Sol – Gels:

Sol: - A material which when reacts with liquid converts in to a gelly or viscous fluid. Colloid:-

A substance which converts liquid to semisolid or viscous or cloudy.

Gel : Amore thicky substance.

Soot :- When a compound is brunt, it given black fumes called soot.

In solutions molecules of nanometer size are dispersed and move around randomly and hence the solutions are clear. In colloids, the molecules of size ranging from 20 μm to 100 μm are suspended in a solvent. When mixed with a liquid colloids look cloudy or even milky. A colloid that is suspended in a liquid is called as sol. A suspension that keeps its shape is called a gel. Thus sol-gels are suspensions of colloids in liquids that keep their shape. Sol -gels formation occurs in different stages.

- 1) Hydrolysis
- 2) Condensation and polymerization of monomers to form particles
- 3) Agglomeration of particles. This is followed by formation of networks which extends throughout the liquid medium and forms a gel.

The rate of hydrolysis and condensation reactions are governed by various factors such as pH, temperature, H₂O/Si molar ratio, nature and concentration of catalyst and process of drying. Under proper conditions spherical nanoparticles are produced.

3. ELECTRODEPOSITION:

This method is used to electroplate a material. In many liquids called electrolytes (aqueous solutions of salts, acids etc) when current is passed through two electrodes immersed inside the electrolyte, certain mass of the substance liberated at one electrode gets deposited on the surface of the other. By controlling the current and other parameters, it is possible to deposit even a single layer of atoms. The films thus obtained are mechanically robust, highly flat and uniform. These films have very wide range of application like in batteries, fuel cells, solar cells, magnetic read heads etc.

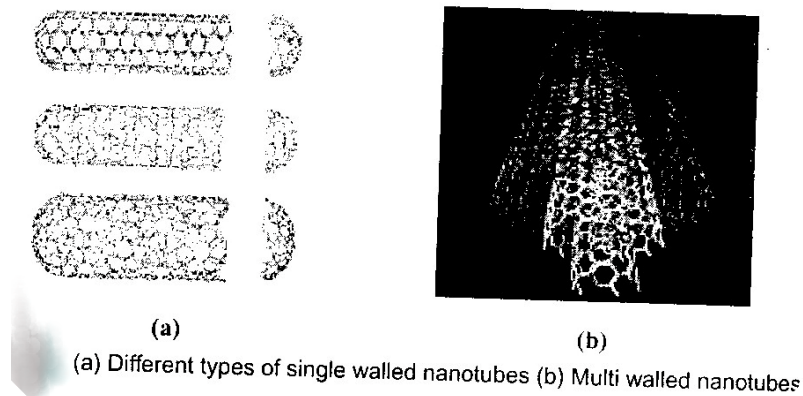
5. BALL MILLING (MECHANICAL CRUSHING):

In this method, small balls are allowed to rotate around the inside of a drum and then fall on a solid with gravity force and crush the solid into nanocrystallites. Ball milling can be used to prepare a wide range of elemental and oxide powders. Ball milling is the preferred method for preparing metal oxides.

CARBON NANOTUBES (CNT'S):

We know three forms of carbon namely diamond graphite and amorphous carbon. There is a whole family of other forms of carbon known as carbon nanotubes, which are related to graphite. In conventional graphite, the sheets of carbon are stacked on top of one another

.They can easily slide over each other. That's why graphite is not hard and can be used as a lubricant. When graphite sheets are rolled into a cylinder and their edges joined, they form carbon nanotubes i.e. carbon nanotubes are extended tubes of rolled graphite sheets.



TYPES OF CNT'S: A nanotube may consist of one tube of graphite, a one atom thick single wall nanotube or number of concentric tubes called multiwalled nanotubes.

There are different types of CNT'S because the graphite sheets can be rolled in different ways .The 3 types of CNT'S are ZigZag, Armchair and chiral. It is possible to recognize type by analyzing their cross sectional structures.

Multiwalled nanotubes come in even more complex array of forms. Each concentric single – walled nanotube can have different structures, and hence there are a variety of sequential arrangements. There can have either regular layering or random layering .The structure of the nanotubes influences its properties .Both type and diameter are important .The wider the diameter of the nanotube, the more it behaves like graphite.

The narrower the diameters of nanotube, the more its intrinsic properties depends upon

its specific type. Nanotubes are mechanically very strong, flexible and can conduct electricity extremely well.

The helicity of the graphite sheet determines whether the CNT is a semiconductor or metallic.

PRODUCTION OF CNT'S: There are a number of methods of making CNT'S few method adopted for the production of CNT'S.

ARC MRTHOD: This method creates CNT'S through arc- vapourisation of two carbon rods placed end to end, separated by 1mm , in an enclosure filled with inert gas at low pressure .It is also possible to create CNT'S with arc method in liquid nitrogen. A direct current of 50-100A, driven by a potential difference of 20V apprx, creates a high temperature discharge between the two electrodes .The discharges vapourizes the surface of one of the carbon electrodes, and forms a small rod shaped deposit on the other electrode. Producing CNT'S in high yield depends on the uniformity of the plasma arc, and the temperatures of deposits forming on the carbon electrode.

LASER METHOD: CNT'S were first synthesized using a dual-pulsed laser. Samples were prepared by laser vapourizations of graphite rods with a 50:50 catalyst mixture of Cobalt & Nickel at 1200⁰c in flowing argon. The initial layer vapourization pulse was followed by a second pulse, to vapourize the target more uniformly. The use of two successive laser pulses minimizes the amount of carbon deposited as soot. The second laser pulse breaks up the larger particles ablated by the first one and feeds then into growing nanotube structure. The CNT'S produced by this method are 10-20nm in diameter and upto 100m or more in length. By varying the growth temperatures, the catalyst composition and other process parameters the average nanotube diameter and size distribution can be varied.

CHEMICAL VAPOUR DEPOSITION (CVD): Large amount of CNT'S can be formed by catalytic CVD of acetylene over Cobalt and Iron catalysts supported on silica or zeolite. The carbon deposition activity seems to relate to the cobalt content of the catalyst; where as the CNT'S selectivity seems to be a function of the PH in catalyst preparation. CNT'S can be formed from ethylene. Supported catalysts such as iron cobalt and Nickel containing either a single metal or a mixture of metals, seem to induce the growth of isolated single walled nanotubes or single walled nanotubes, bundles in the ethylene atmosphere. The production of single walled nanotubes as well as double walled CNT'S, molybdenum and molylodenum-iron catalysts has also been demonstrated.

PROPERTIES OF CNT'S :

Few unique properties of CNT'S are

1) ELECTRICAL CONDUCTIVITY: CNT'S can be highly conducting , and hence can be said to be metallic. Their conductivity will be a function of chirality, the degree of twist and diameter. CNT'S can be either metallic or semi conducting in their electrical behaviour. Conductivity in multi walled CNT'S is more complex .The resistivity of single walled nanotubes ropes is of the order of 10^{-4} ohm –cm at 27°c .This means that single walled nanotube ropes are most conductive carbon fibers. Individual single walled nanotubes may contain defects. These defects allow the single walled nanotubes to act as transistors. Similarly by joining CNT'S together forms transistor - like devices. A nanotube with natural junctions behaves as a rectifying diode.

2) Strength and elasticity: Because of the strong carbon bonds, the basal plane elastic modulus of graphite, it is one of the largest of any known material. For this reason,

CNT'S are the ultimate high strength fibers. Single walled nanotubes are stiffer than Steel, and are very resistant to damage from physical forces.

3) THERMAL CONDUCTIVITY AND EXPANSION: The strong in- plane graphite carbon- carbon bonds make them exceptionally strong and stiff against axial strains. The almost zero- in -plane thermal expansion but large inter - plane expansion of single walled nanotubes implies strong in plane coupling and high flexibility against non- axial strains. CNT'S show very high thermal conductivity. The nanotube reinforcements

in polymeric materials may also significantly improve the thermal and thermo mechanical properties of composites.

4) HIGHLY ABSORBENT: The large surface area and high absorbency of CNT'S make them ideal for use in air, gas and water filtration. A lot of research is being done in replacing activated charcoal with CNT'S in certain ultra high purity application.

APPLICATION OF NANOMATERIALS:

- 1. Engineering:** i).Wear protection for tools and machines (anti blocking coatings, scratch resistant coatings on plastic parts). ii) Lubricant – free bearings.
- 2. Electronic industry:** Data memory(MRAM,GMR-HD), Displays(OLED,FED), Laser diodes, Glass fibres
- 3. Automotive industry:** Light weight construction, Painting (fillers, base coat, clear coat), Sensors, Coating for wind screen and car bodies.
- 4. Construction:** Construction materials, Thermal insulation, Flame retardants.
- 5. Chemical industry:** Fillers for painting systems, Coating systems based on nano composites. Impregnation of papers, Magnetic Fluids.
- 6. Medicine:** Drug delivery systems, Agents in cancer therapy, Anti microbial agents and coatings, Medical rapid tests Active agents.
- 7. Energy:** Fuel cells, Solar cells, batteries, Capacitors.
- 8. Cosmetics:** Sun protection, Skin creams, Tooth paste, Lipsticks.

Questions:

1. What are Nanomaterials? Why do they exhibit different properties?
2. How are optical, physical and chemical properties of nano particles vary with their size.
3. How are electrical, magnetic and mechanical properties of nano particles vary with their size?
4. How are nano materials produced?
5. What are carbon nano tubes? How are they produced?
6. What are the different types of carbon nano tubes? What are their properties?
7. What are the important applications of nano materials?

ASSIGNMENT QUESTIONS



CMR ENGINEERING COLLEGE
Kandlakoya (v), Medchal Road, Hyderabad -501401

I.B.TECH II SEM-I ASSIGNMENT QUESTIONS

Subject: AP

BRANCH: MECH

Marks: 5X1=5 M

Answer all the following questions

- 1) Explain stress and strain. Discuss the stress-strain diagram.
- 2) a) Derive relation between Y&K.
b) Derive expression for work done in deforming a body.
- 3) Discuss Torsional pendulum experiment and derive expression for rigidity modulus of a material.
- 4) a) define reverbaration , reverberation time and absorption coefficient.
b) Derive Sabine's formula of absorption coefficient.
- 5) Discuss in detail factors affecting the architectural acoustics and their remedies.

Applied Physics IInd mid assignment questions(2016-17)

1. a) Discuss any one method to detect and measuring the velocity of ultrasonic waves.
b) What is non-destructive testing? Explain the use of ultrasonic waves for non-destructive testing.
2. What is internal field of a dielectric and how it is calculated for a dielectric? Deduce Clausius-Mosotti relation.
3. Explain about ferro, piezo and pyroelectricity.
4. a) Define the terms: magnetic field strength, magnetic flux density, magnetization and magnetic susceptibility.
b) What are the sources of magnetic moment? Derive expression for Bohr magneton.
5. a) What is domain? Explain ferromagnetic hysteresis on the basis of domains.
b) What are soft and hard superconductors? Explain their properties.

Applied Physics I-mid question paper

Branch: Mechanical

Answer any two questions

- 1) a) Explain the following terms. CO1 (2M)
i) Stress ii) Strain iii) Hooke's law iv) Elastic limit.
b) Derive relation between Y&K. (3M)
2. a) Discuss Torsional pendulum experiment and derive expression for rigidity modulus of a material. CO2 (4M)
b) A Cu wire 2m long and 62.5 m^2 in cross section is found to stretch 3mm under a tension 1kN. Find the Young's modulus of wire. (1M)
3. a) Explain about reverberation and reverberation time. CO1 (2M)
b) Explain about transmission of sound and transmission loss. (2+1M)
4. a) Discuss in detail any four factors affecting the architectural acoustics and their remedies. CO2 (2M)
b) Describe the production of ultrasonic waves by magnetostriction method. (3M)



CMR ENGINEERING COLLEGE

KANDLAKOYA(V),MEDCHAL, HYDERABAD-501 401

I B.Tech II-Sem

APPLIED PHYSICS MID-II Paper

Time:1hrs.

Marks:10

Answer any two questions

1. a) Explain ionic polarization and derive an expression for ionic polarizability. (2.5 M)
 b) What is NDT? Explain one experimental method. (2.5 M)
2. a) What is internal field of a dielectric and how it is calculated for a dielectric? (3 M)
 b) Discuss about BaTiO₃ structure. (2 M)
3. a) Explain about properties of dia, para and ferro magnetic materials (2.5 M)
 b) What is domain? Explain ferromagnetic hysteresis on the basis of domains. (2.5 M)
4. a) What are soft and hard magnetic materials? Explain their properties (2.5 M)
 b) What is superconductor? Explain applications of superconductor. (2.5 M)

SCHEME OF EVALUATION

1M	1M	1M	1M	1M	5M
Definition	Circuit /Diagram	Theory	Derivation	Result/conclusion	Total



CMR ENGINEERING COLLEGE

KANDLAKOYA(V),MEDCHAL, HYDERABAD-501 401

I B.Tech II-Sem

JNTUH APPLIED PHYSICS Model Paper

Time:3hrs.

Marks:75

Answer all questions

Part-A

- | | | | |
|----|----|---|---|
| 1. | a) | Define the terms: stress, strain and poisson's ratio. | 3 |
| | b) | What are the factors affecting elasticity. | 2 |
| | c) | Define musical sound and noise. | 2 |
| | d) | Explain the terms: absorption coefficient and transmission loss. | 3 |
| | e) | Define magnetostriction effect and piezo electric effect. | 2 |
| | f) | What are the applications of ultrasonic's? | 3 |
| | g) | Define the terms: dielectric constant, electric displacement, polarizability and electric susceptibility. | 2 |
| | h) | Explain pyro-electricity. | 3 |
| | i) | Derive relation between χ_m and μ_r . | 2 |
| | j) | What is Meissner effect? Explain. | 3 |

Part-B

- | | | | |
|----|----|--|---|
| 2. | a) | Explain briefly the stress-strain diagram. | 4 |
| | b) | Derive relation between Y,K and ρ . | 6 |

OR

- | | | | |
|----|----|---|---|
| 3. | a) | Derive the expression for work done in deforming a body. | 3 |
| | b) | Discuss about torsional pendulum experiment and derive expression for rigidity modulus of a material. | 7 |
| 4. | a) | Explain the various requirements for acoustically good hall. | 5 |
| | b) | Explain reverberation time. Deduce the Sabine's formula for the reverberation. | 5 |

OR

5. a) Explain various factors affecting architectural acoustics and their remedies. 6
b) Explain various methods of acoustic quieting. 4

6. a) Explain the production of ultrasonic waves with neat diagram by magnetostriction method. 7
b) What are the properties of ultrasonic waves? 3

OR

7. a) What is meant by non-destructive testing? Explain. 4
b) Explain the use of ultrasonic waves for non-destructive testing. 6

8. a) Explain electronic polarization and derive an expression for electronic polarizability
b) Discuss about BaTiO_3 structure. 6+4

OR

9. a) What is internal field of a dielectric and how it is calculated for a dielectric? 6
b) Deduce Clausius-Mosotti relation. 4

10. a) Explain the properties of dia, para and ferro magnetic materials. 6
b) What is domain? Explain ferromagnetic hysteresis on the basis of domains. 4

OR

11. a) What is superconductor? Explain applications of superconductor. 5
b) What are soft and hard magnetic materials? Explain their properties. 5

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